Report of the Results of an IMS Learning Design Expert Workshop

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***Abstract*—An IMS Learning Design Expert Workshop was held at the University of Vienna on November 20 & 21, 2008. This report contains a description of the purpose of the workshop, its methodologies and results. Participating experts first brainstormed visions and problems of IMS Learning Design (IMS LD), and then developed potential solutions to some of the identified problems. Three groups formed to work on two of the identified problems in more depth: the usability and utility problem, and the life cycle of a unit of learning problem. The proposed solutions regarding the usability and utility problem were to investigate how teachers' and learners' representations of a learning design can be brought together, and to set up a research program to identify how teachers cognitively proceed when designing courses and to map this knowledge to IMS LD. In regard to the life cycle of a unit of learning problem, the group suggested a system that continually exchanges information between runtime and editing systems so that units of learning can be updated accordingly.**

***Index Terms*—IMS Learning Design, future, problem, solution.**

I. BACKGROUND AND PURPOSE OF THE WORKSHOP

A. *The IMS Learning Design Specification*

IMS Learning Design (IMS LD) was introduced in 2003 as a specification that represents a "framework of elements that can describe any design of a teaching-learning process in a formal way" [1]. The requirements for this framework were specified as follows:

Completeness: fully describe the teaching-learning process in a unit of learning.

Pedagogical Flexibility: express the pedagogical meaning and functionality of data elements within a unit of learning; flexible to describe all different kinds of pedagogies while not prescribing any specific pedagogical approach.

Personalization: describe personalization aspects within a learning design, so that the content and activities can be adapted to users.

Formalization: describe a learning design in a formal way, so that automatic processing becomes possible.

Reproducibility: describe the learning design so that repeated execution in different settings with different persons is possible.

Interoperability: support interoperability of learning designs.

Compatibility: use standards and specifications where possible.

Reusability: make it possible to identify, isolate, de-contextualize and exchange useful learning artifacts, and to re-use these in other contexts.

In the six years since its introduction, a number of projects have placed foci on developing tools for IMS LD and have applied the specification to different areas of teaching and learning. Examples of such projects include RELOAD[1], UNFOLD[2], COLLAGE [2], GRAIL[3], LD4P[4], TENCompetence[5], and PROLIX[6]. Next to a great number of conference and journal articles on IMS LD, the book "Learning Design" [3], and special issues in Educational Technology & Society ("Current Research in Learning Design[7]"), as well as in the Journal of Interactive Media in Education ("Advances in Learning Design[8]" and "Adaptation and IMS Learning Design[9]") were published that provided reference examples for course and tool developers.

B. *The Expert Workshop*

Expertise for IMS LD has been built across Europe through a number of different projects. The purpose of the workshop was to funnel this expertise by having experts of IMS LD share the problems they have encountered regarding the specification, and to jointly develop approaches to solve these problems. Participants took

1 http://www.reload.ac.uk/
2 http://www.unfold-project.net/
3 https://gradient.it.uc3m.es/xowiki/main_page
4 http://www.jisc.ac.uk/whatwedo/programmes/elearningpedagogy/ld4p.aspx
5 http://www.tencompetence.org/
6 http://www.prolixproject.org/
7 http://www.ifets.info/index.php?http://www.ifets.info/issues.php?id=30
8 http://jime.open.ac.uk/2005/01/
9 http://jime.open.ac.uk/2007/01/

different perspectives towards the IMS LD specification, the main perspectives being pedagogical and technical. The experts participating during the workshop came from industry as well as higher education (participants appear with their affiliations in alphabetical order):

- Tom Boyle (London Metropolitan University, UK)
- Francis Brouns (Open University of the Netherlands, The Netherlands)
- Luis de la Fuente Valentín (Universidad Carlos III de Madrid, Spain)
- Michael Derntl (University of Vienna, Austria)
- Michele Dicerto (Giunti Labs, Italy)
- Nils Faltin (imc AG, Germany)
- Dai Griffiths (University of Bolton, UK)
- Davinia Hernández-Leo (Universitat Pompeu Fabra, Spain)
- Hans Hummel (Open University of the Netherlands, The Netherlands)
- Michael Klebl (FernUniversität in Hagen, Germany)
- Petra Oberhuemer (University of Vienna, Austria)
- Amir Wasim (imc AG, Germany)
- Moderator: Susanne Neumann (University of Vienna, Austria).

II. WORKSHOP METHODOLOGY

Workshop participants first created a vision about the question: "What do you envision IMS Learning Design to be ten years from now?" Each participant wrote on index cards answers to this question. The cards were then collected and pinned onto a pin board, and each participant explained for his or her cards what the answers entailed. The outcomes of this portion of the workshop are contained in the full version of this report, which can be accessed online.

The participants then described problems, which they encountered during their work with the specification. Again, the problems were written on index cards and collected on a pin board. Once all the problems were collected, participants grouped them in a joint effort. Each card stating a problem was discussed among the participants regarding its relevance to other problems, i.e. whether it fitted with an existing group of problems, or whether it represented a new idea that would start a new group. Using this method, five main problems (i.e. groups of problems) emerged.

After the identification of the main problems, participants voted which problems interested them the most for further discussion during the remaining time of the workshop. Each participant had three votes to cast (in the form of small round stickers), which could be distributed in any way across the main problems identified. The color of the stickers differed for those having a (mainly) pedagogical perspective and for those having a (mainly) technical perspective on IMS LD. This way, interdisciplinary problems could be distinguished from problems that interested specifically one of the perspectives.

To form groups for group work, the three main problems that received the most votes were included in a second round of voting. Participants were asked to place their name tag onto one of the three problems to identify who would be working towards solutions for what problems. When the name tags had been placed, participants wished to work on two problems during remainder of the workshop.

Three groups were formed for the group work phase of the workshop. To start off the group work, all participants jointly brainstormed "influence factors", i.e. factors that could be changed or adjusted to tackle the problem. Groups then formed and started developing solutions to the problems. They first formulated a problem and goal statement. Then, a solution was developed which was described on a poster along with the estimated effort of implementation and the barriers to implementation.

The groups presented their solution posters to all participants. This was followed by a short discussion. To wrap-up the workshop, the participants voted on the vision statements that were initially put forth. They were asked to indicate how the developed solutions related to the visions, i.e. what visions were worked towards with the proposed solutions.

III. PROBLEMS WITH IMS LD

Participants brainstormed the question "What problems have I encountered in regard to IMS Learning Design?" Participants each received three cards onto which to write the problems (one problem per card). They wrote the problems and silently (without explanation) pinned them to the pin board. When reading each others problems, participants had the opportunity to write new problems onto cards.

Once the collection of problems was finished, participants grouped the problems with the help of a moderator. Five groups emerged from the identified problems, and each problem group was given a name. The identified problems are listed hereafter in alphabetical order so as to not imply value judgments. A breakdown of the vote regarding what problems seemed most pertinent to be worked on during the workshop is reproduced in section III.F. The forthcoming sections IV, V, and VI describe next to concrete problem statements also potential solutions to the problems that the workgroups propose.

A. Adoption

For the problem group Adoption, the workshop participants saw the following sub-problems:

- There is tension between complexity and functionality [of a learning design]. One of the main problems of IMS LD that hinders its adoption is its complexity. It is a specification with many elements and three levels (A, B, C) of complexity, with level B being the most difficult to use since it allows designers to exploit conditions and program adaptation features to control the learning flow, or to enable the upload of activity outcomes (e.g., reports, problem solutions), among others. Despite the broad functionality possibilities that IMS LD provides, there is still a number of facilities that the community is demanding (e.g., services, features for establishing groups). Therefore, there is a tension between the complexity already entailed by the specification and the functionality the community would like IMS LD to offer.

- There is a lack of IMS LD implementation in organizations, probably due to the needed organizational change, which is difficult.
- To get started on IMS LD, there is a high threshold to overcome. The threshold comprises cultural and technological hurdles.
- It is not quite apparent to stakeholders, yet, what the core and key benefits of IMS LD are.
- Next to IMS LD, there are several competitive specifications (IMS Common Cartridge, Moodle-zip etc.).

B. Interoperability

For the problem group Interoperability, the participants saw the following sub-problems:

- Data flow: The flow of data between activities can be controlled using IMS LD level B properties. However, it is not possible to manage the flow of data between the tools (or services) supporting the activities or between the tools and the activities since the tools are "black boxes" to the learning design [4].
- Global properties: how to manage global properties defined by other specifications like IMS Question & Test Interoperability [5]?
- Collaboration services: More types and standard parameters are needed for these.
- IMS LD services need to be extended to include rising technologies.
- Should each service be clearly specified in IMS LD, creating a heavy-weight specification, or should an approach like the current web 2.0 formats be adopted for services?

C. Level B Notation

This problem group includes problems that specifically relate to Level B of the IMS LD specification. The sub-problems contained in this group are:

- Using IMS LD Conditions is not easy, especially because the overview of what condition serves what purpose can be easily lost.
- Current IMS LD editors do not achieve good usability for designers to integrate level B elements in their learning designs.
- It is unclear, how acts are synchronized with level B: Do properties and conditions work around acts?
- Declarative language: IMS LD is a declarative programming language which enables expressing logic (what a program should accomplish) without describing its control flow (how the logic should be accomplished). When implementing sophisticated pedagogical methods (such as project-based learning with adaptation features), learning technologists sometimes ask for an imperative-oriented language capable of specifying more detailed descriptions of the programs to be run.

D. Life Cycle

For the problem group Life Cycle, the participants saw the following sub-problems:

- Editing [a learning design] is currently not integrated within the runtime system. To make changes to a unit of learning, it must always be returned to the editing software.
- There is an incomplete cycle between the authoring phase, the deployment phase, and the enactment phase and then again with the authoring phase.
- There is currently a lack of runtime flexibility: Once the unit of learning is "running" in a learning management system, hardly any changes can be made to it.
- Working process: How to go about building and employing units of learning?
- Creating groups of the same role represents a problem.

E. Usability & Utility

The last group of problems is Usability & Utility. The sub-problems of this group are:

- What happens in the "real world": learning objects can be used for learning as well as face-to-face learning situations.
- Teachers' concepts (of teaching and learning) may not be consistent with the concepts IMS LD foresees.
- There is a lack of authoring support, ranging from the conceptual mapping of a unit of learning to the actual XML coding support.
- The question of granularity: What are good choices of granularity for the different IMS LD components (activities, acts, plays, units of learning)?
- Visualizations for IMS LD: The abstractions and visual (or graphical) representations [6] of the concepts used in the authoring and enactment time should be closer to the understanding of their final users, i.e. closer to the teachers and learners. Also, visual representations may differ depending on teachers' and learners' profiles and the learning situation or context.
- IMS LD editors currently offer no unit of learning preview options of what the unit of learning looks like when executed in a learning management system.
- How to treat learning objects & the different layers of design within an IMS LD unit of learning?
- IMS LD player: How to represent the learning path in the user interface? Navigation support is not clearly defined by the IMS LD specification.
- Diagrams of activities are missing.

F. Voting on Main Problems

After having grouped the problems, participants voted on the problem that each person would work on during the remainder of the workshop. In a first round of voting, each participant received three round stickers, whereby each sticker represented one vote. The stickers could be placed on any of the main problems previously identified, i.e. all three dots could end up on the same problem, or they could be distributed across three different problems. A distinction was made between participants that had a (mainly) technical perspective and participants that had a (mainly) pedagogical perspective on IMS LD – the two perspectives received differently colored stickers to tell them apart. This way, the interdisciplinarity of problems could be identified. Table I shows the distribution of votes.

TABLE I.
DISTRIBUTION OF VOTES REGARDING THE FIVE MAIN PROBLEMS OF IMS LEARNING DESIGN

Group of Problems	Number of Technical Votes	Number of Pedagogical Votes	Total Number of Votes
Adoption	3	2	5
Interoperability	3	1	4
Level B Notation	2	0	2
Life Cycle	3	5	8
Usability & Utility	4	8	12

Participants were then asked to place their name tag onto one of the three main problems that received the most votes. This was to indicate which problem participants wanted to work on during the remaining time of the workshop.

As a result, participants decided to work on two of the identified problems: Life Cycle and Usability & Utility. Since the number of participants, who assigned themselves to the latter problem, was quite large, this group was split into two. Therefore, two groups worked on the Usability & Utility problem. Memberships in each group were as follows:

Workgroup: Life Cycle

- Francis Brouns
- Hans Hummel
- Luis de la Fuente Valentín
- Petra Oberhuemer

Workgroup: Usability & Utility I: IMS Learning Design and Teaching Practice

- Michael Klebl
- Nils Faltin
- Michele Dicerto
- Michael Derntl

Workgroup: Usability & Utility II: Joining Teachers' and Learners' Representations of Learning Designs

- Dai Griffiths
- Davinia Hernández-Leo
- Tom Boyle
- Amir Wasim

For the print version of this report, we include the problem statements and the solution descriptions that each workshop group created in the following sections. For complete descriptions of workgroup results including influence factors, goal statements as well as effort of and barriers to implementation, please refer to the online version of this report.

IV. RESULTS OF THE LIFE CYCLE WORKGROUP

(Authors of this section: Luis de la Fuente Valentín, Hans Hummel, Francis Brouns and Petra Oberhuemer)

A. Problem Statement

First, we discussed who our target group is. Currently, the lack of easy-to-use, end-user authoring tools means that IMS learning designs are created and developed by expert designers. These experts often are not the same people, who are involved in course delivery. Normally, teachers and tutors will change a course during its runtime. Obvious changes to be made are typing errors, or more elaborate changes become necessary due to unexpected events (e.g. students dropping out due to illness). Even students might make changes to a course design such as pointing out typing errors. Teachers might want to include student contributions like products of assignments in the course. These types of users, teaching staff and students, are not likely to have access to an advanced IMS LD authoring tool, let alone have the competences to create designs. However, these users should be supported in making relevant changes to the course, at least during the runtime of a particular course. When we want to close the lifecycle from authoring to runtime, it becomes particularly important to support teaching staff and students.

A person could easily spot mistakes or discover changes that need to be implemented, especially mistakes that a designer could not foresee when creating the learning design. Continuous checking for mistakes might be too labor-intensive (think of hyperlinks to websites which have to be kept up-to-date). Data collected automatically during the actual use of the course could suggest changes, which are not obvious but which could be determined by analyzing the system, log, and user generated data. This could result in suggested changes like a current recommender system offer. Of course, there are some privacy issues to consider as there are with any automated change maintenance.

The IMS LD behavioral model is exposed linearly and does not make reference to any possible course modification after instantiation. Therefore, it can be said that IMS LD neither defines nor suggests a proper method to reuse changes made after the course has been deployed. The workgroup Life Cycle discussed this topic, identifying three key problems.

The first key problem is the lack of runtime flexibility. As mentioned above, the specification guidelines do not consider course modification after a unit of learning's deployment; resolving this issue is left to runtime environments. As a result, existing IMS LD players do not provide change management functionalities. Answers to questions like, "Should changes be made to a specific run, or to all course instances?" would simplify development and management.

The second key problem regards versioning. Each course modification is a new package version. Thus, integrating runtime flexibility in platforms will demand a robust definition of a package versioning system, in order to deal with change reverts, branches, multiple authors etc.

Last but not least, most authoring tools cannot import compliant units of learning if they were created with different software. This lack of functionality in authoring software, in conjunction with the first two key problems, prevents the course life cycle from being fully closed.

B. Solution Description

As a possible solution, our group has proposed a hybrid approach to modeling and refining learning material, attempting to preserve the best of both worlds, i.e. to benefit from the advantages while at the same time limiting the disadvantages of both the top-down and bottom-up approaches. The solution entails a two-layered design structure. The first layer comprises top-down imposed, fixed templates, which are modeled according to IMS LD. This template layer has a joint interface to the second layer, which contains bottom-up generated, flexible evaluations and course extensions (using, for instance, a wiki for storage). The second layer contains all “feedback” data collected during the course implementation. The two layers are then connected via a mechanism that feeds most needed and most popular changes from the feedback data layer back into the LD-templates of the first layer. Hybridly combining fixed ontologies with flexible social behavior (this is the same as the two-layered design structure) has recently been successfully applied in providing personalized recommendations in learning networks [7]. Therefore, the setup of the proposed solution has been justified.

During our brainstorm, we sketched a rough outline of the two-layered design approach without describing details of the concrete solution. In our initial brainstorming we thought about using a wiki for storing runtime behavior. The wiki is used to store runtime behavior while the course is running. Both, the learning management system and the unit of learning participants, write in the wiki. The wiki also stores who is making changes to the unit of learning at what point in time. A set of services could (automatically) feed information from the wiki to the layer containing the LD-templates.

The higher level layer contains the “master plan of pedagogy”, i.e. the generic templates that correspond to various pedagogical patterns. The templates are modeled and stored in IMS LD (e.g. like in the Graphical Learning Modeller [8]). These templates were provided by expert designers and can be deployed via an import process to the lower layer. The lower layer contains the specific details of the course like activity descriptions. In the lower level hints on where to put descriptions are provided.

The lower level layer would contain specific content to be added to the generic templates as well as the interactions between that content and actors during runtime. The wiki would be flexible and emerge continuously from the bottom up by user generated content and comment (presuming). These data could be exported as new (generic) template to the higher layer. The runtime environment (learning management system) is thus used as an authoring environment and you can view the result directly in the platform.

The question is how could we feed back information from the lower layer to inform and actually change the higher level templates in order to close the life cycle? This is where our idea of data mining comes into play. User behaviors exhibited on the lower level (things that users do while learning with the unit of learning) can be channeled into the higher layer as modifications. This mechanism needs to be as labor-extensive as possible to warrant sustainability and independence from experts. It would involve specifying the data flow (by means of an Application Programming Interface (API)) between the services, which would require rules about the importance or minimal popularity of the comments. Experts may have to specify these rules in advance. An example for a needed rule is an answer to the question when actual content or user behavior should be fed back to the IMS LD layer.

Such activities modeled in IMS LD would not have a pre-designed learning activity structure (on a higher, top-down level), but rather this structure would emerge from the collective behavior of the students (lower level of actual behavior and interactions in the network). Like described by Hummel et al. [7], we used indirect social navigation and collaborative filtering (data mining) techniques to derive the advice. When most peers having the same or similar user profile would have successfully completed B after having completed A (data stored in a transition matrix), it would be most likely that A, B, ... would become the 'standardized' sequence for these students. After passing a certain threshold (certainty of at least 70%, after occurring at least in 100 cases), these formations could be revised and stored within the overall learning design. Similar examples can be conceived for the formation of groups, most popular content to study, et cetera.

We still have to decide what set of (communication) services is needed as well as if these services should be loosely (open interface) or tightly integrated and specified.

V. Results of Workgroup Usability and Utility I: IMS LD and Teaching Practice

(Authors of this section: Michael Klebl and Michael Derntl in cooperation with Nils Faltin and Michele Dicerto)

A. Problem Statement

Starting from being highly innovative, IMS LD as a technology still has to make its way to everyday practice in technology-enhanced learning. The problem statements subsumed under issues of usability and utility stand for one general assumption described by theories of technology adoption and diffusion: In everyday life, people interact with artifacts, not with technology. In order to attain a large and significant impact beyond research and development, technology has to be implemented in marketable products like tools and applications, which prove their utility in real life situations [9].

Considering IMS LD as a technology, its acceptability can be described in terms of practical acceptability as well as in terms of social acceptability [10]. Focusing on practical acceptability, the impact of interoperability standards is influenced by factors of technical scope, expressiveness and quality, as well as, of course, by the effects of networks and critical mass (cf. [11]). However, besides technical and economic factors, and given social acceptance, usefulness is the key factor for the integration of technology in everyday life. Usefulness can be described in terms of usability and utility (cf. [12]). Utility relates the functionality of a system to the needs of users. The acceptance of a technology depends on the benefits people gain from its use. These benefits should not be considered as purely functional and rational. Affective and emotional benefits like status and enjoyment also foster the adoption of technology. Usability then relates functionalities to the interaction of humans with technical systems. Usability determines how users can actually make use of functionalities. Usability of tools and applications in its various facets (like ease of use, learnability, task efficiency, but also hedonistic quality) causes utility and allows for the perception of benefits from a technology. However, usability of tools for teaching and learning has to connect to the everyday practice of teachers and learners, employing terms, symbols, metaphors, processes and interactions from the field of application. Starting from these considerations, we define usability matters as a first key problem.

IMS LD has not proven its usability and utility in real life situations on a large scale yet, and if so, the wider community of educators concerned with technology-enhanced learning was not reached and convinced by reports and publications on the results [13, 14]. Hence, we consider communication to practitioners and stakeholders in education beyond the discussion within the scientific community related to IMS LD to be the second key problem.

B. Solution Description

After an analysis of ways and means to advance towards the stated goals, our working group agreed to propose further research and development activities with regard to usability and utility of IMS LD-related tools and applications. However, these activities in research and development are supposed to focus on practice, application, and impact rather than on theoretical foundations of both pedagogical and technical aspects. To facilitate the implementation, the group devised a number of concrete activities ranging from multiple small scale projects to complex programs.

Research Program on Educators' Proficiency, Cognition and Action related to IMS LD: In order to bring IMS LD to the everyday practice of educational experts in different areas of education and training in a way that both educators and learners benefit considerably, it is indispensable to comprehend the practice of educators thoroughly. This comprises educators' proficiency, cognition and action, which inform and control the design of learning experiences, e.g. while preparing lessons, developing learning environments or guiding students through learning scenarios. How could IMS LD be used to support these design processes? With regard to a cognitive level, this is connected to the learning biography of teachers from novice to expert; it is indispensable to understand the growth of educational expertise. The understanding of how teachers act on the base of tacit knowledge will give insights on how IMS LD and related tools add to the process of teachers' proficiency.

This would be best framed as an interdisciplinary, multi-institutional research project covering three years time, e.g. a Specific Targeted Research Project (STREP) in the 7th Framework Programme for Research and Technological Development of the European Commission (FP7).

Timeline-based representation of activities in IMS LD: Flowcharts are a common way to represent activities in IMS LD and to allow their graphical aggregation to a learning design. Flowcharts document a process flow quite expressively; yet, they lack an immediate representation of time. Other visualizations of processes, like Gantt charts, establish a timeline in order to better represent scheduled events. Since schedules are often important for the design of a course, there is a need to develop graphical representations for IMS LD that comprise a timeline, time limits and targeted dates. In addition to the provision of a tool for designing units of learning, this representation would help to communicate with learners about the learning scenario.

This development could be well undertaken within current projects on IMS LD.

Unknown ways of visualizing IMS LD: The activity tree, which was inspired by the object tree, is a simple way to visualize IMS LD. However, this representation is owed more to the structure of XML documents (IMS LD units of learning) than to the requirements of the users. Process charts like flow charts and Gantt charts are taken over from process modeling, but are still not widespread amongst teachers. Hence, there is an opportunity to investigate unknown ways of visualizing the structure of a learning experience denoted in IMS LD in a few creative, divergent and experimental projects. An idea to realize this is to work with an arts academy.

An additional facet of this aspect is the technical terminology used by IMS LD. Practitioners with different backgrounds may use different terms for concepts modeled in IMS LD, or may have different views on the meaning and relationships of these concepts (e.g., method, activity, activity structure, environment, learning object, role, etc.). Previous research (e.g. [8]) has suggested that this gap between the language of practitioners and the terminology of the specification may pose entry and usage barriers and thus hinders the widespread adoption of IMS LD. Alternative forms of visualizing or localizing IMS LD units of learning might be successful in overcoming this gap by abstracting from technical details (e.g., by employing different metaphors) and providing more user-centered interfaces to the specification and its artifacts.

These projects could be well assigned to several students for a thesis in graduate studies or to PhD students.

Marketing campaign for IMS LD: As already stated, the wider community of educators concerned with technology-enhanced learning either hasn't been reached or hasn't been convinced by the notion of IMS LD. There are common misunderstandings on IMS LD, like the idea of IMS LD being restrictive and fostering teacher-centered instructional design as mentioned in the analysis for the integration of IMS LD and Moodle [15]. Hence, there is a need to start a marketing campaign in order to bring the notion of IMS LD, with its focus on activities of learners and teachers, and the notion of IMS LD as a modeling tool similar to CAD software in engineering (data chain from the sketch to the implementation, and in order to depict the production chain of an educational measure) to different areas of educational practice. This marketing campaign has to reach vendors of learning management systems and content providers beyond academia and should rely on networking within as well as beyond Europe.

This marketing campaign needs a strong association of stakeholders interested in the dissemination of IMS LD and adequate funding.

VI. RESULTS OF WORKGROUP USABILITY AND UTILITY II: JOINING TEACHERS' AND LEARNERS' REPRESENTATIONS OF LEARNING DESIGNS

(Authors of this section: Dai Griffiths and Davinia Hernández-Leo in cooperation with Tom Boyle and Amir Wasim)

A. Problem Statement

Our working group has formulated the following problem statement: “The representations of the teachers’ designs are not consistent with the representations of learners’ designs.”

From some perspectives this is not a problem. There is often a difference between authoring views and user views, for example, in most programming tasks. If the development of a unit of learning were equivalent to a programming task, then there is no problem with having different representations. A (pedagogic or technical) expert designs a learning activity, which is then delivered to the learners so that they can follow the steps, which the expert has determined. This will move the learner on to a new understanding.

In some contexts, however, it is important that the learner either

1. understands the reason why a particular activity has been proposed, and how it fits with other activities, or
2. participates with the teacher in determining the learning activities to be followed, for example, by choosing alternatives, or by participating in the design process itself.

Point 1) has not been properly explored in the current IMS LD approaches and tooling. Until the moment, many efforts have been devoted towards exploiting the potentials of IMS LD as an instrument for teachers or designers but not explicitly for learners. This issue is motivated by the following sub-problems of the global problem statement:

- The process followed and reasoning used by the teacher when creating the learning designs is not captured in the final design and therefore is not presented to the learners. This is a general problem of instructional design but can also partially be attributed to IMS LD because it only contains limited elements for description.
- The way of visualizing the learning designs may depend on the user role and their objectives. Teachers need to be supported during the authoring, but they also have to fulfill a teacher role at runtime. For each role, different visualizations may prove useful. The support required may be also different depending on the teacher’s background (e.g., humanistic vs. science background resulting in a preference for text or diagrams, respectively) and the educational context (high school vs. Open University).
- There is some research on representations for teachers (see, for example, [6]). However, further investigations on learners’ representations and their consistencies with teachers’ abstractions are needed.
- Learners should be guided through the learning process. The visual guidance and abstract representations provided to learners may depend on the pedagogical ideas behind the learning design.
- The activity tree, which is commonly used in current IMS LD players to depict the learning design, may not be the most appropriate way of representing designs. Learners don’t like it, but there is currently no alternative or better way.

Point 2) has to do with what we refer to as 'participatory' design. In view of this, we can expand the problem statement to the following:

Participatory learning design is an important strategy in some pedagogic perspectives, but it has so far been hard to work with IMS LD using this approach. This is due to two reasons:

- IMS LD editors are hard to use, for teachers and for learners.
- The representation of units of learning at runtime is quite different from the representation at design time due to the separation and differing setup of design and runtime environments.

Progress is being made on the ease of use of IMS LD editors. It remains to be seen if the current level of improvement is sufficient, and whether achieving the needed balance between expressivity of a learning design and usability of the editing software proves problematic. Little or no work is being done towards representations of learning designs intended for teachers that are consistent with those intended for learners, or indeed full convergence of the two views.

We note further that this discussion is closely related to some of the ideas recently discussed by Sue Bennett of Wollongong University [16]. In the case of the Learning Activity Management System (LAMS), one of the interesting uses of the application was for teachers to be able to discuss learning activities with learners, and to plan future activities with them. As LAMS is inspired by IMS LD, we take this as an indication that a participatory approach to IMS LD is not unreasonable.

B. Solution Description

The teacher has an idea or intent on how to structure the instruction. S/he goes through a complex and iterative authoring process, constantly refining, making the instructional idea explicit. When the teacher is satisfied with the representation of his or her idea, s/he creates an IMS LD unit of learning and places it into the player or learning management system. Teachers and learners are given access to this orchestration. Inside the player, the teacher recognizes his or her instructional intent both in the design representation and in the orchestration of the unit of learning. S/he recognizes the context for the orchestration. The teacher knows why certain activities and resources are appearing because s/he has developed the instruction over a set of iterations. The player orchestrates the activities by parsing the teacher’s design decisions and supporting the learners’ and teachers' actions. The learners, on the other hand, only see the results of the orchestration, as they are revealed. The learners lack the original development context that the teacher had, meaning that they don’t see the reasons why activities were chosen and placed in the sequence at hand.

Functionality is required which enables the learners to see the intent behind the unit of learning’s resources and activities. Providing this information could at the same time be useful to other teachers, who wish to reuse and adapt the unit of learning for their own teaching. How should the unit of learning as a whole be represented to the learner? First ideas, how this may be achieved, are presented below.

- Giving learners a choice and/or control over the representation of the unit of learning in the forms of:

  - A printed output
  - Runtime system presents the teacher's ideas
  - A running commentary that is part of the unit of learning
  - A combination of views
- "Intelligent parsing": this would merge choices of learners and choices of teachers regarding wanted instructional elements. The runtime system automatically, i.e. "intelligently", parses the choices into the orchestration creating a flexible setup of a unit of learning.

Further, we can consider if the learner can be directly involved in the design of the learning activities (when this is pedagogically appropriate). An exemplary use case where this would take place is in teacher education. This would require an environment where the learners and teacher(s) can design together. To keep things simple, this suggests an environment where the design-time and runtime systems have similar or identical interfaces. On the other hand, we remember that the reason that the interface is different at design time is that there is more complexity at this stage. The variety of the available options at design time is higher than the variety of the options available at runtime. If the interfaces are to be the same then this may mean a sacrifice of functionality and available choices as a compromise between design and runtime interfaces is established.

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